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A LIVING PLESIOSAUR?: A CRITICAL ASSESSMENT OF THE DESCRIPTION OF *CADBOROSAURUS WILLSI*

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ABSTRACT: The biological interpretations made by Bousfield and LeBlond in their description of *Cadborosaurus willsi* (*Amphipacifica*, Vol. 1, Suppl. 1) are critiqued. There appears to be little support for their contention that the animal is a living plesiosaur. In particular, their reconstruction of locomotor morphology is inconsistent with that of all known plesiosaurs. We interpret the holotype of *C. willsi* to be a decomposed shark, and suggest that observations of "adult" *Cadborosaurus* may be based on large pinniped sightings. Cryptozoological specialization should be encouraged in order to ensure that investigations of unknown animals are conducted so as to meet the rigours of critical review.

INTRODUCTION

Cryptozoology as a science suffers from an image problem. Many critics (often uninformed) regard cryptozoology as the bailiwick of the fringe element, of credulous individuals with no real credentials as scientific researchers. Certainly, the field does attract a disproportionate number of adherents whose interests tend to the bizarre, and even to the supernatural. However, as a glance through the pages of the journal *Cryptozoology* will reveal, professional zoologists, anthropologists, linguists, and folklorists, as well as dedicated amateurs, are also intrigued by the field, and have established a credible record of objectively analyzing data pertinent to unknown animals (e.g., LeBlond and Collins 1987, Winn 1991), or applying data from other fields to cryptozoology (e.g., Buffetaut 1983, Brussard 1986).

Further, despite criticism to the contrary, cryptozoological research (either planned or serendipitous) has resulted in the discovery or rediscovery of a number of cryptozoans (see Raynal 1989 for a review of cryptozoological successes), and has even satisfactorily resolved questions of the origin of mythical beasts (Mayor 1991, Mayor and Heaney 1993). Perhaps the ultimate tribute to the dedication of cryptozoologists is that "mainline" peer-

reviewed scientific journals have been willing to publish research articles of a cryptozoological nature (e.g., Bodley 1988, Oren 1993, Pierce et al. 1995).

The most recent appearance of a cryptozoological paper in a scientific journal is the description of *Cadborosaurus willsi,* a large "sea serpent" from the Straits of Georgia, British Columbia, by Edward L. Bousfield and Paul H. LeBlond (Bousfield and LeBlond 1995). This was published in a new journal, *Amphipacifica,* that is ostensibly devoted to the systematics of invertebrates (especially amphipods) of the Pacific marine coastal region of North America. This would appear a rather strange place to publish a paper that describes a living plesiosaur, a view that was apparently shared by two of the three members of that journal's editorial board (the third member, the managing editor, being co-author Bousfield himself), who published a dissenting opinion in the same issue, justifying their opposition to publication of the paper (Staude and Lambert 1995).

Although we welcome another peer-reviewed outlet for systematic works (and for cryptozoological topics), we have major misgivings about the description of *Cadborosaurus willsi,* and believe the paper to be flawed both in premise and execution. We here present our objections, not as an attack on the authors, nor as a denial of the existence of a large, unknown marine animal species in the Straits of Georgia, but, rather, as a part of the necessary self-policing of cryptozoology as a discipline. Whereas most critics of cryptozoology seek to find poorly executed studies in order to debunk the discipline as a whole, we endeavor to provide as rigorous analysis of the data as possible, in an effort to salvage the data but discard interpretations that cannot be justified by these data.

Bousfield and LeBlond (1995) build their case on the basis of ethnological, testimonial, and zoological evidence. The latter is based primarily on photographs and interpretations of a supposed carcass of *Cadborosaurus* that was obtained from the stomach of a sperm whale flensed at Naden Harbour, in the Queen Charlotte Islands, British Columbia, in July, 1937. Also cited are observations of a captive juvenile. In analyzing the contribution by Bousfield and LeBlond (1955), we take as our premise the primacy of the zoological data in the case. That is, we will base our interpretations chiefly on the evidence from the Naden Harbour specimen, and what it does and does not (and can and cannot) tell us about *Cadborosaurus.* This approach differs from that of Bousfield and LeBlond (1995), who are credulous in their acceptance of all potential interpretations. By relying on the observational information as gospel truth, they place biology in a secondary position. They are forced by this approach to eliminate from consideration all interpretations that are not consistent with the eyewitness accounts, and thereby are led to biologically implausible or impossible conclusions. Any misinterpretations by witnesses are thus translated into inalterable truths, and the evidence from material evidence, common sense, and scientific reasoning are accepted or rejected in accordance with their compatibility with this gospel.

For example, they treat suggestions that whalers might not recognize parts of known animals as an affront to the whalers, despite the fact that Heuvelmans (1968) and others (Anonymous 1977) have shown that competent seafarers, as well as trained zoologists, have been confused by other such finds.

The ethnological evidence presented is largely irrelevant to the existence of *Cadborosaurus*. An atlatl pictured by Bousfield and LeBlond (1995) may or may not depict this animal, but the authors must consider alternative explanations. Such a device, because it is a functional entity and not merely an ornament, has a required size and shape, and, as in the spandrels of San Marco (Gould and Lewontin 1979), the designs used to decorate it are likely to be secondary to the function of the artifact. To insist that representations of unknown animals in artwork confirm the current or former existence of cryptozoans is to deny that mythology is a part of the culture, or, rather, that mythology must be based on physical reality. Although sometimes, as in the case of griffins in Greek mythology, there may be biological explanations for "fanciful" creatures (Mayor 1991, Mayor and Heaney 1993), in other cases allegorical or symbolic origins are clearly suggested. No biological models for the minotaur, for example, are likely to be forthcoming. We maintain that the authors cannot, without more extensive argument, accept some aspects of Indian legend and tradition as supportive of their contention that a plesiosaur survives in the Canadian Pacific, while at the same time dismiss other attributes (such as the ability to fly) that are inconvenient for their proposition. The long and consistent history of a "sea serpent" does not make it real. Only incontrovertible physical evidence can do that.

We have divided up our approach to the analysis of the case presented by Bousfield and LeBlond (1995) for *Cadborosaurus* into sections that deal with different aspects of the zoological evidence and its interpretation. Our evaluation does not cover every point raised in their paper, but goes into sufficient depth to indicate, we posit, that their evidence, as presented, falls far short of making a convincing case, both in terms of substance and critical interpretation.

Nomenclatural Issues

Although non-specialists may regard the rules of nomenclature as the arcane regulations of a Victorian science, they are, in fact, the precepts by which systematists function. They provide guidelines for the maintenance of nomenclatural stability, and the recognition of legitimately described taxa. Although most modern systematists are interested in evolutionary or phylogenetic relationships, nomenclature and classification are the components of systematic study that most often interface with non-specialists. This, above all else, should argue for the significance of the rules of zoological nomenclature. To be sure, there is disagreement within the specialist com-

munity about details of the International Code of Zoological Nomenclature, and many aspects are likely to be modified in the fourth edition of the Code, due to be published in 1997. Indeed, an alternative code, based on phylogenetic principles, has been proposed (de Queiroz and Gauthier 1992, 1994), but even this would affect only certain aspects of the current Code, primarily at higher levels of hierarchical inclusiveness.

The description of *Cadborosaurus* is flawed by a series of very basic errors with respect to type designation, suggesting that the task was not taken very seriously. Most fundamentally, the nature of the type concept seems to have eluded the authors. A holotype is the single specimen designated as the name-bearing type of a species. Paratypes are specimens, other than the holotype, that constitute the type series. Bousfield and LeBlond (1995) have designated one photograph of the Naden Harbour specimen as the holotype of *Cadborosaurus willsi,* and another photo of the same specimen as a paratype. First, a photo or other illustration cannot serve as a type of a taxon. Article 72(c)(v) of the International Code of Zoological Nomenclature clearly states that "in the case of a nominal species-group taxon based on an illustration or description or on a bibliographic reference to an illustration or description, the specimen illustrated or described and not the illustration or the description" is the type (International Commission on Zoological Nomenclature 1985). Therefore, the holotype is the now lost or destroyed material which appears in the photographs. Second, only one individual organism was used in the description, so there is no paratype.

Bousfield and LeBlond (1995) purport to provide diagnoses of adult, juvenile, and newborn specimens of *Cadborosaurus willsi.* However, diagnoses are applied to species, not individual specimens, and their function is to differentiate the taxon under consideration from all others (in practice, this usually means from congeners or other closely-related forms), not to serve as a description. Descriptions (essentially, what the authors have presented as diagnoses) are typically based on the holotype, and may be supplemented by information from other type material. Some features in the "diagnosis" (=description) of the type, such as humps, are not seen or preserved in the type. In other respects, the "diagnoses" of the different age groups are in direct conflict. For example, there are no scales in the type, but the putative newborn is very scaly.

Phylogenetic Concerns

A very basic flaw in the paper is that the authors apparently decided that *Cadborosaurus* was probably a plesiosaur, and then pressed this point, despite the fact that virtually all available evidence does not support this interpretation. Of course, *Cadborosaurus* might have a highly derived body form with respect to other plesiosaurs, but this would require unwarranted

assumptions, and would certainly not be a parsimonious interpretation of the data. (And to make such an assertion, one would expect that the authors would be able to claim considerable expertise in plesiosaur anatomy and systematics, which they certainly cannot.) By making this allocation, Bousfield and LeBlond (1995) have, of course, fixed the higher order placement of *Cadborosaurus*. Thus, they refer the species to the Class Reptilia (a paraphyletic group), and frequently refer to the "reptilian" features of their new species. Strictly speaking, because they are paraphyletic, "reptiles" cannot be diagnosed as a group, and thus have no unifying shared-derived features.

Setting this criticism aside, however, the authors provide no information of any general traits that would allow them to conclude that *Cadborosaurus* is reptilian. Indeed, features such as an ability to remain submerged indefinitely are clearly inconsistent with any air-breathing tetrapod. Likewise, the high surface area to volume ratio, combined with the cold temperatures of its presumed native waters, would not support the idea that *Cadborosaurus* has a typical "reptilian" metabolism. Significant heat production has been reported in one aquatic reptile, *Dermochelys coriacea,* but this ability is, at least in part, dependent on the low surface area to volume ratio of this large marine turtle (Frair, Ackman, and Mrosovsky 1972). On the other hand, elongate marine reptiles, such as the sea snake *Pelamis platurus,* are apparently unable to raise body temperature much above ambient water temperature (Dunson and Ehlert 1971), and are therefore limited to tropical waters.

Within the Reptilia, Bousfield and LeBlond (1995) further refer the species to the Euryapsida, now generally regarded as a polyphyletic group (Carroll 1988). This term is essentially meaningless, and its use suggests unfamiliarity with the modern literature. Dispensing with these issues, could there still be some validity in their allocation of the species to the Plesiosauria? How do the morphological features they discuss conform to the known features of plesiosaurs? In a word, poorly.

Among the features of *Cadborosaurus* are its elongate, attenuate body. This is not seen in any of the known plesiosaurs, which, in fact, have rather deep, barrel-like bodies with very robust girdles, entirely inconsistent with the slender body illustrated by Bousfield and LeBlond (1995). Further, the massive coracoid plate of plesiosaurs forms an inflexible shield spanning several vertebrae, and the abdomen is further reinforced by bony gastralia. Such a configuration would limit body flexion (even if the ludicrous vertebral angles proposed for *Cadborosaurus* were theoretically possible on the basis of their anatomy), and would preclude the body-looping described (see below).

Cadborosaurus, as reconstructed by Bousfield and LeBlond (1995), has a very short tail that is supposedly attached to the hind flippers by means of a fleshy membrane. Despite the obviously short "tail" in their illustrations, the authors, in their text, suggest a somewhat longer appendage, although it

is still quite short. All known plesiosaurs have tails of at least moderate length, and do not resemble the reconstruction in Fig. 13A of Bousfield and LeBlond (1995) in the slightest.

Post-Cranial Osteology and Locomotion

The morphology of the locomotor apparatus is one of the most troubling aspects of the Bousfield and LeBlond (1995) interpretation. Bauer (1991) has previously cautioned against the reconstruction of improbable, if not impossible, morphologies in the attempt to reconcile physical evidence with testimonial accounts. In this case, the authors fully accept accounts claiming that the animal moves by throwing its body into tightly bent standing waves that are oriented vertically in the water. Muscles ripple on the animal, but the loops do not move. This almost unbelievably inefficient form of movement is achieved with the aid of a locking mechanism to hold the vertebrae in place, and is supposed to be a method of drag reduction.

Bousfield and LeBlond (1995) report that *Cadborosaurus* is capable of swimming speeds of up to 40 m.p.h. (64 k.p.h.). This is near the upper limits of aquatic locomotion, even for primary swimmers, including the fastest teleost fishes. However, the shape assumed by the body when near the surface induces large amounts of drag, increasing at these high speeds. Drag has several components: 1) friction drag; 2) pressure drag; 3) induced drag; and 4) wave drag. Shape changes affect friction drag and pressure drag differently, and a fineness ratio (body length/mean diameter of 4.5) generally yields minimal drag. Whales and ichthyosaurs, as well as some pliosaurs and plesiosaurs, fall close to this ideal (Massare 1988). Only short-necked plesiosaurs (e.g. *Cryptoclidus,* but not *Cadborosaurus*) would come close to this. Even for a "well-designed" 2.8 meter plesiosaur, a typical speed would have been 2.3 m/sec (8.28 km/h). Examining 18 specimens of 10 species, ranging in length from 2.49 to 12.56 meters (still short of the dimensions of *Cadborosaurus*), Massare (1988) calculated speeds of 2.17–2.51 m/sec. Alexander (1989) similarly estimated slow swimming speeds for this group, consistent with Robinson (1975), who postulated pliosaurs as sprinters, and plesiosaurs as slow endurance swimmers.

Bousfield and LeBlond (1995) claim that dorso-ventral flexion is a real possibility for plesiosaurs, or at least this plesiosaur, arguing from the evidence that Mesozoic crocodilians were probably capable of intervertebral excursion in this plane (Buffetaut 1983). However, it is a far cry from a moderate bow in the back to a series of sine waves along the trunk, especially since corcodilians and plesiosaurs are not closely allied. Vertebral number is fixed in any post-embryonic vertebrate. Thus, juveniles cannot add vertebrae, and could only change proportion by differentially changing the length of individual segments. As mentioned elsewhere, amniotes do not undergo metamorphosis, so any major restructuring is essentially ruled out. There-

fore, the morphology of the Naden Harbour "juvenile" should serve as model of the locomotor apparatus that any *Cadborosaurus* would have to work with.

From the photograph of this specimen, Bousfield and LeBlond (1995) estimate 26 dorsal vertebrae. Because "five or more" body loops, coils, or humps have been reported (and accepted by them), the animals must be able to throw the body into five loops with only 25 points of bending. This would require incredible amounts of excursion at each intervertebral joint. For contrast, Gasc (1974) found that angles of 10° were the approximate maximum between adjacent vertebrae in snakes. The vertical looping described by Bousfield and LeBlond (1995) occurs in no known vertebrates, the closest approximation perhaps occuring in a defensive posture assumed by certain small snakes, such as the Australian elapid *Vermicella annulata* (Shine 1980), although in this instance the pose is static and is accomplished by a body with many more vertebrae (between 200 and 300) than suggested for *Cadborosaurus.*

It is not necessary, however, to argue specific angles with the proposed mode of locomotion, since existing evidence from known plesiosaurs (not cited by Bousfield and LeBlond 1995) is clearly inconsistent with a highly flexible plesiosaur. In *Pachypleurosaurus,* Carroll and Gaskill (1985) reported 19–20 trunk vertebrae. These possess several accessory articulating structures that would "have made rotation of the vertebrae around the long axis nearly impossible, and might have also restricted lateral flection [sic] of the trunk. . . . It appears to have formed an almost rigid structure in the living animal."

Indeed, although no primary literature on the subject was cited by Bousfield and LeBlond (1995), plesiosaur locomotion is well known and has been the subject of much recent research. Although differing in detail, there is a consensus among vertebrate paleontologists and functional morphologists that plesiosaur locomotion was oscillatory and limb-based, rather than undulatory and axial.

Both girdles form extensive plates of bone, and the limbs are subequal, enlarged, broadened paddles. The forelimbs were braced by massive coracoid bones (Nicholls and Russell 1991). Locomotion probably involved horizontal movement of the limbs in some combination of rowing and subaqueous flying (Robinson 1975, Taylor 1981, Tarsitano and Reiss 1982, Godfrey 1984, Carroll and Gaskill 1985, Massare 1988). Nothosaurs, with smaller limbs and longer tails than other plesiosaurs, may have paddled (Carroll and Gaskill 1985) or also used underwater flight (Sanz 1980). There were almost certainly asymmetrical power and recovery strokes (Godfrey 1984, Tarsitano and Reiss 1982, Frey and Reiss 1982), and locomotion may have been sea lion-like (Godfrey 1984, Taylor 1986).

Even the static appendicular morphology of plesiosaurs appears to have

been misrepresented by Bousfield and LeBlond (1995). Their Fig. 13C, for example, is problematic. It is supposed to represent the pelvic girdle of the plesiosaur *Cryptoclidus,* and to be derived from a popular book by Norman (1985). However, it matches exactly the pelvic girdle of *Pachypleurosaurus* illustrated in their Fig. 18, and taken from Carroll (1988: Fig. 12–4). Because this figure, as reproduced, is disassociated from the body, its orientation is incorrect, and it is this erroneous view that is applied as a model for the reconstruction.

The figure of *Cryptoclidus* in Norman (1985), however, is indeed the source of their Fig. 11. In the original illustration of the entire skeleton, the left foreflipper is seen in ventral view, as if it were raised at the end of the recovery stroke of the limb. However, in Bousfield and LeBlond (1995), the ventral view of the left flipper has been reconstructed as a dorsal view of a right foreflipper, and the digits are labeled incorrectly, with the fifth in the preaxial location, and the first situated postaxially. Thus the leading edge of digit one, as labeled, is actually the trailing edge of digit five.

The long neck, supposedly with 10 vertebrae (again based on the Naden Harbour specimen), has fewer vertebrae than have been recorded for plesiosaurs (Carroll and Gaskill 1985). The purpose of the long neck is supposedly to aid the animals in determining their position relative to the shore. This point is assailable on several fronts. If this is crucial to the animals, how do they orient at night? Second, it is likely that eyes that are "designed" for life in the mesopelagic zone may not be useful for distance vision in air. For example, sea turtles can accommodate in water, but have very poor vision in air (Underwood 1969). Thirdly, massive neck musculature would be required to support a huge neck and large head out of the water. In association with this, one would expect enlarged neural processes on the anterior trunk vertebrae for attachment of these muscles (or a stout ligament). These, according to the Naden Harbour photos, are not present in the type of *Cadborosaurus.*

Respiration

The authors indicate that *Cadborosaurus* rarely comes to the surface, and can remain submerged indefinitely. This feature is not known in any amniotes. All amniotes require atmospheric oxygen while active over long periods. Although some may function anaerobically for short periods (Seymour 1982), the debt must be compensated for within a relatively short period of time. As counter examples, Bousfield and LeBlond (1995) present information about turtles that utilize buccopharyngeal linings as gas exchange surfaces, and are consequently able to remain submerged for long periods. While this does occur in some forms, as does cloacal respiration (Legler and Cann 1980, Seymour 1982, King and Heatwole 1994a), total non-pulmonary oxygen exchange capacity is still generally far below pul-

monary levels. In sea snakes, which use the integument as a gas exchange surface, the skin may account for up to 33 percent of total oxygen uptake (Heatwole and Seymour 1975), although the mean value approximates only 22 percent. The Bousfield and LeBlond (1995) claim that some euryapsids used non-pulmonary methods of respiration is both unknowable and indefensible.

Bousfield and LeBlond (1995) suggest that the large surface area to volume ratio characterizing *Cadborosaurus* would be beneficial, as it would provide a greater area for gas exchange. They fail to take into account, however, the fact that amniote skin is characterized by an outer keratinized investment that is largely impermeable to water and retards gas exchange (Lillywhite and Maderson 1982). The only known chordates to use the integument as the primary site of gas exchange are some juvenile fishes, cephalochordates, plethodontid salamanders, and a small number of other amphibians. All have thin, non-keratinized skin, and very small body size. Among amniotes, some sea snakes and turtles may use integumentary respiration as a supplemental means of gas exchange, but even this is limited (Seymour 1982).

The so-called mane reported in some eyewitness accounts of *Cadborosaurus* has also been cited to be a respiratory surface. This would only provide a limited amount of additional gas exchange surface. Further, such structures would of necessity be delicate, and their exposure to air and their subsequent clumping might cause damage. When in the water and traveling at 40 m.p.h. (64 k.m.p.), the strands would be adpressed to the body and/or to each other, increasing total surface area by a neglible amount. Further, these structures would need to be highly vascularized if they were to function in respiration (King and Heatwole 1994b), and they would provide a likely spot for the loss of metabolically produced body heat, a fatal "adaptation" in the cold waters of British Columbia. Among tetrapods, only in *Trichobatrachus robustus,* an anamniote without appreciable keratinization, are hair-like projections of the skin used as supplemental gas exchange surfaces (Noble 1925).

Reproduction

Bousfield and LeBlond (1995) suggest live birth for *Cadborosaurus,* citing the general features of viviparous reptiles to be precociality and the small size of offspring. The former is certainly true, but most live-bearing reptiles (except for snakes) give birth to few very large young. *Trachydosaurus rugosus* is a case in point. In this large Australian skink, single or twin births are the rule, and body mass of the newborn may be 20 percent of the post-parturition weight of the female (Green 1995). Live-bearing geckos also produce twins of large size (Cree 1994).

Although they do not fully endorse this interpretation, Bousfield and LeBlond (1995) consider that *Cadborosaurus* may be anadromous. This would require that adults of 65–100 feet (20–30 m) in length migrate up

rivers perhaps as much as 100 miles (160 km) in order to give birth. Such an animal may go unnoticed in the vastness of the ocean, but probably not in a narrow river channel. It is assumed that, unlike anadromous fishes such as salmon, which spawn and die in fresh water, *Cadborosaurus* adults return to the sea (or else there would certainly be an occasional observation of the large rotting carcasses in inland waters). Although the saltwater crocodile, *Crocodylus porosus,* and other species of living "reptiles" are capable of surviving in either salt water or fresh water, none have anadromous life cycles, and no known living form that is essentially obligately aquatic makes the shift.

Some of the features attributed to the newborn *Cadborosaurus* are not evident in the illustration by Haglund provided by Bousfield and LeBlond (1995). The yellow fuzz reported on the venter is certainly not compatible with any "reptilian" structure, but might represent a mass of small yellow eggs carried on the abdomen by a crustacean. The tail illustrated looks very fishlike, but might also represent the telson of a decapod. In any event, the rather drastic differences between juvenile and adult or subadult in *Cadborosaurus* suggest that metamorphosis of some type must occur, yet no amniotes undergo metamorphosis. In *Pachypleurosaurus,* the proportions of bony elements remain relatively constant across the range of body sizes known (Carroll and Gaskill 1985), in contrast to the situation in *Cadborosaurus,* in which there are supposedly marked allometric changes in ontogeny.

Lifestyle

The reconstruction of the lifestyle of *Cadborosaurus* is entirely conjectural, and many of the points made by Bousfield and LeBlond (1995) are incompatible with what is known of plesiosaurs. The use of nasal passages as resonating chambers is suggested. This has been demonstrated in some archosaurs, including hadrosaurian dinosaurs (Hopson 1975) and modern birds (Alexander, Houston, and Campbell 1994). In these organisms, however, this was only determined through careful comparative anatomical techniques unavailable for *Cadborosaurus* because of the lack of material. Further, even in the living hornbills, the role has not been established unambiguously. Echolocation has also been proposed for *Cadborosaurus.* However, Taylor (1992) and Taylor and Cruickshank (1993) indicated that there was no acoustic isolation of the otic capsules in pliosaurs or plesiosaurs, suggesting that they had no form of echolocation.

The fish-trap jaws (not seen in the Naden Harbour specimen nor illustrated in the eyewitness drawings presented by Bousfield and LeBlond 1995) said to be a feature of *Cadborosaurus* are generally associated with obligate fish feeding. Nonetheless, it is reported to feed on squid at depth and on seabirds at the surface. The assumption that feeding is snakelike is totally untenable.

A chief feature of snake feeding is streptostyly (the condition of having a highly mobile quadrate), which is absent in plesiosaurs.

The reported distribution of *Cadborosaurus* in the water column is pure speculation. The habitat of the animal is presented rather authoritatively as depths close to 3,300 feet (1,000 m). This is based on the fact that the 1937 specimen was recovered from a sperm whale stomach, and that this is near the deepest record or estimate of sperm whale diving.

Individually, these reconstructions of the lifestyle of *Cadborosaurus* from virtually no evidence might be excusable, but, together, along with other aspects not discussed here, they form an elaborate and totally unfounded picture of an animal that may not even exist. The describers of rare and poorly known animals are certainly entitled to speculate on the habits of their new finds. But such speculation is generally grounded in the morphology of specimens actually in hand, and on inference from closely related forms about which more is known. Given that neither are available for *Cadborosaurus*, we believe that it would have been prudent for Bousfield and LeBlond (1995) to eschew discussions of pheromones, echolocation, and other biological traits not preserved and visible in the photos of the holotype of *C. willsi*.

WHAT IS *CADBOROSAURUS*?

We have attempted to demonstrate that Bousfield and LeBlond (1995) have not provided convincing evidence for a living plesiosaur in the waters of British Columbia. If we are correct, what, then, is *Cadborosaurus*? Or, more appropriately, what are the sources for the evidence presented for the existence of a cryptozoan in the Straits of Georgia? In invoking Ockham's razor, we should look for the simplest explanation that fits the available data. We believe that known organisms can most parsimoniously account for the testimonial evidence regarding "adults," the "sub-adult" holotype in the Naden Harbour photograph, and the "newborn" specimen seen by W. A. Hagelund. Each presumptive life stage is clearly different from the others in some aspects, and we regard it most likely that a different kind of animal has served as the basis for each stage.

The most significant evidence for *Cadborosaurus* are the physical remains photographed in 1937. Bousfield and LeBlond (1995) claim, without justification, that the Naden Harbour specimen was intact, ruling out the possibility that it had been partially digested or decomposed. However, there is a long history of very similar-looking Pacific "sea monsters" that have turned out to be decomposing sharks. A somewhat similar animal, although less fully decomposed (if we are correct), was found by a Japanese trawler off the coast of New Zealand in 1977. It too was thought to be a plesiosaur by some (Koster 1977), but was in all probability the carcass of a shark (Anonymous 1977).

More pertinently, there is also a long history of such animals from the waters of coastal British Columbia. Bousfield and LeBlond (1995) appear to have ignored very significant passages and figures from Heuvelmans (1968), who provided information regarding similar "sea serpents," such as that reported from Henry Island in 1934. The Henry Island monster was "the rotting carcase of an animal about 30 feet in length." It "was reported to have reddish flesh, skin covered with hair mixed with quills, a horse's head and a spinal column upon which one could see what seemed to be where four fins or flippers were attached." It was thought by many at the time that this animal was indeed the "sea serpent" known locally as Cadborosaurus, or Caddy.

The skull and some parts of the vertebral column were examined by the director of the biological station at Nanaimo, and declared to be the remains of a basking shark. However, the keepers of the Provincial Museum, in Victoria, reportedly stated that the remains were those of a Steller's sea cow, a thought-extinct sirenian. Comparisons of the carcass with the skeletons of a sea cow and a basking shark revealed that no particular resemblances between the first two could be noted, but that similarity between the carcass and the basking shark was very marked: "The shape of the skull, the position of the eye-socket, the shape of the vertebrae and even their approximate number, the dorsal ligament joining them together, all agreed exactly. The hairy horse-headed monster of Henry Island was therefore a decomposed large selachian—most likely a basking shark" (Heuvelmans 1968). Plate Fig. 16 in Heuvelmans (1968) shows the remains of the Henry Island monster to be very similar to the *Cadborosaurus* photo in Bousfield and LeBlond (1995), only larger. Another animal, washed up at Effingham in 1946 and also supposed by some to be Caddy (see Heuvelmans 1968), also turned out to be the remains of a basking shark.

In the same year that the Henry Island monster appeared, a similar phenomenon occurred in France, and, again, wildly speculative interpretations were made. The carcass in this case, again a basking shark, was associated with earlier sightings of horse- or camel-headed, fast-moving, serpentine sea creatures. This specimen, known as the Querqueville monster, was less decomposed than the Henry Island animal, which was more like the holotype of *Cadborosaurus* in overall appearance. It should be noted that, in both the Canadian and French examples, seafaring men, who would have recognized the intact animal, were not able to identify the partial remains. On the basis of the Querqueville monster and other cases, Huevelmans (1968) concluded: "It seems to be quite normal for basking sharks to take on a plesiosaur's shape when they decompose. This is because of the peculiar structure of their gill-slits which are extremely long and go almost right round the neck . . . as soon as its tissues decompose and become soft the whole gill apparatus falls away taking the jaws with it, so that nothing remains in front of the

pectoral fins but the tiny skull and the spinal column clad in its muscles and thus looking like a thin neck. At the other end of the body, the lower fluke of the tail soon goes with nothing to support it, since the spine extends only into the upper one. The body then seems to have a long thin tail." Huevelmans (1968) also indicated that decomposition of the skin results in a body that gives the appearance of bearing hair, and that remnants of the dorsal fin may result in a mane-like appearance in the region of the "neck."

Basking sharks are common in British Columbian waters (Compagno 1984), and this seems to be the most likely candidate for the Naden Harbour carcass. Whereas sperm whales may not be known to feed on basking sharks, neither have they been reported to feed on plesiosaurs. This (basking shark) interpretation could be consistent with Francis Kermode's identification of part of the Naden Harbour carcass as "baleen" (see Bousfield and LeBlond 1995) if one takes into account the fact that either the gill rakers of basking sharks or ceratotrichia of the fins of any elasmobranch might be mistaken for this material by someone unfamiliar with these structures.

What of the observations of "adults" at sea? Again, we think that known animals provide the most parsimonious explanation. Our criticism of testimonial evidence is not meant to imply that witnesses have lied, but rather that they may have misinterpreted what they saw. This is easy to do. Size is essentially impossible to estimate at even moderate distances against the featureless background of the water surface, especially since, as the authors admit, these animals are seen only for short periods at the surface. Further, witnesses are usually surprised by the sudden appearance of the animal, and, once they become oriented, have little time to interpret what they see. The sounds of snorting or blowing are consistent with breeching marine mammals. The large eyes reported seem improbable for very large vertebrates, such as whales, as these tend to have relatively small eyes.

Although there are clearly some inconsistencies, we regard pinnipeds, especially the northern elephant seal, *Mirounga angustirostris,* as the most likely candidates for the source of most of the observations reported at sea. These large mammals, measuring up to 16 feet (5 m) (King 1983), are seldom seen at the surface during their annual feeding migrations, which take them past the shallow coastal waters of British Columbia (Banfield 1974). Indeed, they have recently been reported to surface for only 1.6 minutes, with dives lasting as long as 48 minutes (Le Boeuf et al. 1988, Campagna et al. 1975). Significantly, northern elephant seals were only relatively recently confirmed to frequent the coastal waters of British Columbia (Banfield 1974), this being demonstrated in 1944, seven years after the finding of the Naden Harbour specimen. The most problematic aspect of the eyewitness accounts is the reference to the long, slender neck. This leaves the tantalizing possibility that an unknown marine animal having this feature lives in these waters, but such sightings certainly do not justify making the connection to the

Naden Harbour specimen. Thus, we contend that such sightings are unconnected with any physical evidence, and must remain an intriguing side issue to the current case.

The "newborn" *Cadborosaurus* is the most difficult to associate with known forms, and it also combines the most unlikely suite of features. Nonetheless, we feel that the description is perhaps compatible with some decapod crustacean, with the "yellow fuzz" on the abdomen representing an egg mass, and the "overlapping flipper-like fins" of the tail the telson of such an invertebrate. Certainly, whatever the "newborn" was, or is, there seems little, other than geographic proximity, to link it to either the Naden Harbour specimen or the testimonial evidence regarding adult *Cadborosaurus* at sea.

Conclusions

Bousfield and LeBlond (1995) claim that the Naden Harbour photo of the holotype is as good as physical fossil evidence for establishing the existence and identity of *Cadborosaurus*. However, in the absence of realistic models, fossils or photos may be grossly misinterpreted. A case in point is *Hallucigenia* from the Burgess shale, which had been variously interpreted as part of some larger organism, or as a representative of a new and distinct phylum. The discovery of allied fossils, and the recognition that earlier reconstructions had placed the specimen upside down, have revealed that the animal is an onychophoran, or at least a close relative thereof (Ramsköld and Hou 1991). Likewise, conodonts, which remained known only from their enigmatic mouthparts, are now recognized to be vertebrates (Gabbott, Aldridge, and Theron 1995).

It is our contention that Bousfield and LeBlond (1995) selected an inappropriate model for their interpretation of the evidence, and forced improbable conclusions from this. We regard as a fundamental flaw of their interpretation the insistence that three apparently disparate sets of putative information—testimonial evidence, evidence from the specimen photographed, and evidence regarding the tiny "newborn"—are related to one another, and that all, despite their almost total incongruity, refer to one animal.

It is our view that most of the testimonial evidence fits rather well with a pinniped, perhaps the elephant seals that migrate through the area on their way north to their feeding grounds in Alaskan waters. The sighting reports of long-necked animals remain intriguing, but appear to be unrelated to the physical evidence in the photographs, as the morphology is not congruent. The evidence from the 1937 Naden Harbour photos clearly supports a decaying shark, perhaps a basking shark, as the culprit. And the very odd "newborn" is most compatible with a crustacean, or perhaps a teleost fish of some kind.

Bousfield and LeBlond (1995) cite evidence for the discovery of large,

previously unknown or ethnoknown animals as a basis for the plausibility of their own findings. While we do not deny the possible existence of such cryptozoans, we advocate a rigorous approach to their verification. Analysis of such phenomena require that Ockham's razor be invoked, and that explanations that are consistent with known phenomena be accepted as simpler working hypotheses before more tenuous interpretations are embraced. The onus is on Bousfield and LeBlond (1995) to demonstrate why such less controversial interpretations cannot be accepted before building complex arguments based on purely speculative underpinnings.

Albert (1987) argued for specialization in cryptozoology, and we concur. To spread oneself too thin is to make errors, and that is what has occurred in the formal naming of *Cadborosaurus willsi*. In describing a species in a group with which neither author is professionally familiar, Bousfield and LeBlond (1995) have made unwarranted assumptions, and have bypassed virtually all of the appropriate literature that would have channelled them towards some more reasonable interpretation of *Cadborosaurus*.

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